SIGHT TESTING MADE EASY

W. W. HARDWICKE

THIRD EDITION

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SIGHT-TESTING MADE EASY

BY

W. WRIGHT HARDWICKE

M.D.(St. And.), M.R.C.P., L.R.C.S.(Ed.)

THIRD EDITION

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Sight-testing Made Easy. By W. Wright Hardwicke, M.D.St. And., M.R.C.P., L.R.C.S.Ed. (London: J. and A. Churchill, 1910. 2*s.* 6*d.* net.)

Originally intended to be a guide to the practitioner desirous of testing for refractive defects by the subjective method, the author has seen fit in this, the second, edition to add a chapter on retinoscopy. There is no denying that in the case of patients who are compelled by the necessity of earning their living to use their accommodation frequently it is almost impossible to insist on the use of a mydriatic unless the need for so doing is urgent. In this class of patients subjective eye-testing is of decided advantage. Unfortunately, however, the glasses the patient prefers are not always those which he ought by right to be wearing, and the practitioner can only get an approximate idea of the right glasses by this method. Retinoscopy without a mydriatic is by no means easy unless the surgeon has had a good deal of practice in refraction work. On the whole, therefore, it would seem best for the general practitioner—and it is for him the book has been written—to insist on the use of a mydriatic by the patient prior to retinoscopy in all cases in which it is convenient, and always in the case of children. We think, therefore, that Dr. Hardwicke's new chapter is entirely in place, and that the value of the book has been much enhanced by its addition. The little work is in every way reliable, straightforward, and clear, and we heartily recommend it as a preliminary to a perusal of more advanced works on refraction.

—*The Hospital.*

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PREFACE

THIS little manual was originally compiled in the form of notes as aids to memory, and only dealt with Refraction in its *subjective* form. It was thought, however, to be incomplete without a few notes on the *objective* form, generally known as Retinoscopy, and these were added in a second edition. In the present edition the little book has been thoroughly revised, and in some parts re-written. It was not in its original, nor is it now, in its revised and slightly enlarged form, intended to supersede larger and more comprehensive works on Refraction, but merely to act as companion to them, and enable the busy practitioner to test the sight of a patient, and prescribe the necessary correcting glasses, in the shortest possible space of time. To the student it is hoped it may be found helpful as an introduction to the study of Refraction.

W. W. H.

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CONTENTS

ABBREVIATIONS AND SIGNS, MENSURAL EQUIVALENTS viii

PART I.

REFRACTION AND OPHTHALMOLOGY.

PAGE
I. LENSES AND REFRACTION—Lens Scale . 1
II. ANALYSIS AND NEUTRALISATION OF LENSES 5
III. THE REFRACTIVE OR DIOPTRIC SYSTEM . 7
IV. NORMAL VISION AND ACCOMMODATION — Range of Accommodation . . . 11
V. ASTHENOPIA 14
VI. HETEROPHORIA—Esophoria, Exophoria, and Hyperphoria 16
VII. HYPERMETROPIA 17
VIII. MYOPIA 20
IX. ASTIGMATISM 23
X. PRESBYOPIA — Presbyopia with Hypermetropia; Presbyopia with Myopia . . 29
XI. STRABISMUS—Concomitant Strabismus . 31

PART II.

SUBJECTIVE SIGHT-TESTING.

XII. PRELIMINARY NOTES — General; Pin-hole Disc; Cycloplegics; Heterophoria; Spectacles 40

PAGE
XIII. PRELIMINARY TESTS 52
XIV. CONFIRMATORY TESTS 54
HYPERMETROPIC TESTS—Hypermetropia; Simple Hypermetropic Astigmatism; Compound Hypermetropic Astigmatism; Mixed Astigmatism 54
MYOPIC TESTS—Myopia; Simple Myopic Astigmatism; Compound Myopic Astigmatism 58
XV. HETEROPHORIC TESTS—(*a*) Distant Point Muscle Test—Esophoria, Exophoria, Hyperphoria. (*b*) Near Point Muscle Test . 60
XVI. PRESBYOPIC TESTS — Presbyopia; — with Hypermetropia; — with Myopia; — with Hypermetropic Astigmatism; —with Myopic Astigmatism; — with Compound Myopic Astigmatism; — with Mixed Astigmatism 65

PART III.

OBJECTIVE SIGHT-TESTING.

(*Retinoscopy.*)

XVII. General; Mode of Examination; Testing the Shadow 70
XVIII. EXAMPLES—Hypermetropic; Myopic; Astigmatic 75
INDEX 79

ABBREVIATIONS AND SIGNS

Ax.	Axis.	p.p.	*punctum proximum*
B.	Base.	p.r.	*punctum remotum.*
B.E.	Both eyes.	R.V.(E.)	Right vision (eye).
Cyl.	Cylinder.	Sph.	Spheric or sphere.
D.	Dioptre.	+	Convex (*plus*).
G.D.	Greatest defect.	—	Concave (*minus*).
L.D.	Least defect.	○	Together with.
L.V.(E.)	Left vision (eye).	→	Axis horizontal.
Mn.	Meridian.	↓	Axis vertical.

APPROXIMATE MENSURAL EQUIVALENTS.

Centimetres.		Inches.	Centimetres.		Inches.	Centimetres.		Inches.	Centimetres.		Inches.
2·5	=	1	20	=	8	38	=	15	56	=	22
5	=	2	23	=	9	40·5	=	16	58	=	23
7·5	=	3	25·5	=	10	43	=	17	61	=	24
10	=	4	28	=	11	46	=	18	65	=	25½
12·5	=	5	30·5	=	12	48	=	19	70	=	27½
15	=	6	33	=	13	51	=	20	74	=	29
17·5	=	7	35·5	=	14	53	=	21	79	=	31

100 centimetres = 1 metre = 39·37 Eng. in.

10 millimetres = 1 centimetre.

1·0 gram = (15½) 15·432 grains.

0·0013 gram = $\frac{1}{50}$ grain.

0·0003 gram = $\frac{1}{200}$ grain.

1 mil. (cubic centimetre) = 16·9 minims.

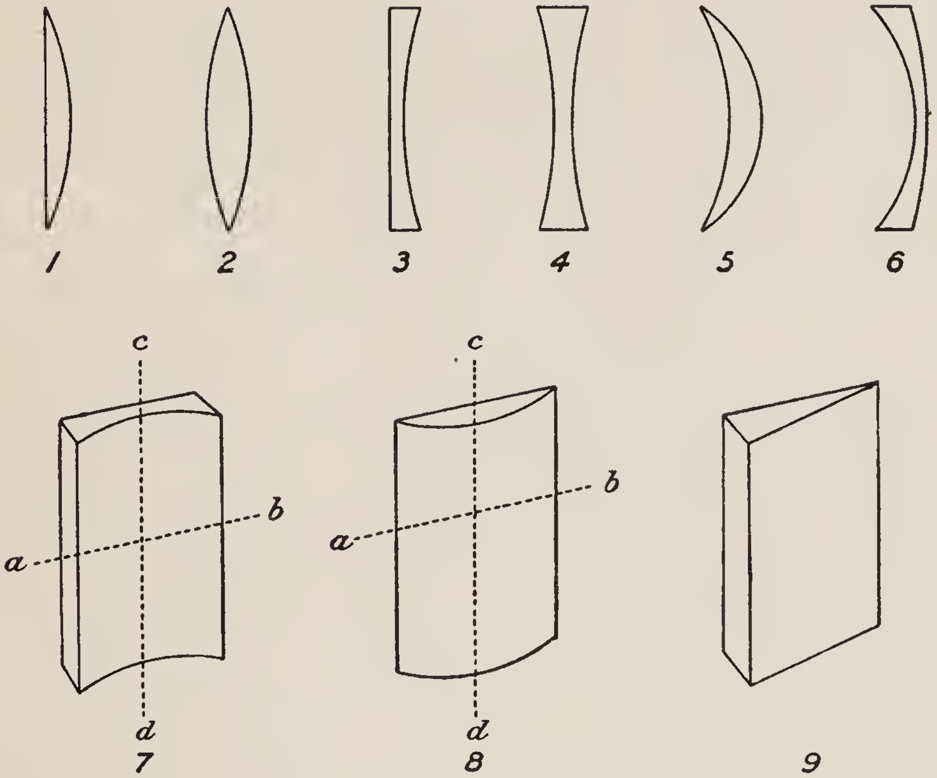
15 mils. = (½ fl. oz.) 4 fl. dr. 13 min,

PART I

REFRACTION AND OPHTHALMOLOGY

I. Lenses and Refraction.

Fig. i.*



1. Lenses may be spherical, cylindrical, or prismatic, and may be used either alone or in

* Note.—The lenses numbered 7, 8, and 9 are shown square for convenience of illustration.

combination. The former two may be either concave (—) or convex (+).

2. Spherical lenses consist of a refracting medium with two opposite surfaces, one or both of which may be segments of a sphere, all the radii being alike. They may be *plano*, *double*, or *periscopic* (περὶ around, σκοπέω I see, *i. e.* increase the distinctness of objects when viewed obliquely). In Fig. i. 1 is *plano-convex;* 2 is *bi-convex;* 3 is *plano-concave;* 4 is *bi-concave;* 5 is *converging concavo-convex*, or *meniscus* (μενισκος a little moon); 6 is *diverging concavo-convex.* The last two are periscopic.

3. A *cylindrical* lens is a lens having one surface (usually) *plano*, while the other is the *segment of a cylinder*, all the radii being different (Fig. i. 7, 8). The two principal *meridians* are those of the greatest and least refraction, and are at right angles to each other, the intermediate meridians increasing or decreasing in a regular ratio. The refracting power is at its maximum in the meridian (*a*, *b*) at right angles to its axis, there being no refractive power whatever in the opposite meridian (*c*, *d*) *i. e.* the meridian of the axis.

4. A *prismatic* lens (Fig. i. 9) is one in

which the refracting surfaces form an angle with each other.

5. Light passes from a luminous body in straight lines, called "rays." These rays diverge, the divergence being proportionate to the distance from the luminous point; the shorter the distance the greater the divergence. If the distance is greater than 6 metres rays are assumed to be parallel.

6. A ray of light meeting a body may be *absorbed*, *reflected*, or—if able to pass through—*refracted*, and the denser the medium, the slower is the ray in passing through. When passing from a rarer to a denser medium (unless exactly perpendicular) a ray is refracted *towards* the perpendicular (of the surface of the latter); passing from a denser to a rarer medium is refracted *from* the perpendicular. When the sides of the media are parallel, the angle of deviation of the "emergent" ray is the same as the angle of the "incident" (or entering) ray; when not parallel, as in prisms, the ray is refracted towards the base, and the deviation is equal to half its angle; thus, a No. 8 prism produces a deviation of the eye of 4°.

7. Parallel rays passing through a spherical lens do not continue parallel, but are refracted,

converging towards a point (the *principal focus*) in the case of convex (*positive*) lenses, and diverging, and consequently never focussing at all, in the case of concave (*negative*) lenses.

8. The distance the principal focus is from the lens is termed the *focal length* or *measurement.*

9. The *principal axis* of a lens is represented by a line passing through the centre (the *optical centre*) at right angles to the surface, through which any ray passing is not refracted. But there are *secondary axes*, by which rays may pass through the optical centre, though not through the principal axis, suffering slight deviation and emerging in the same direction as they entered, but the deviation in thin lenses is so slight that they are usually assumed to pass through in a straight line.

10. Lenses are *numbered* according to their refractive power, and not, as in the old system, according to their focal length. A lens of 1 metre (~~roughly 40 in~~ or 100 cm.) focus is taken as the unit or standard, and is called a *dioptre*, all other lenses being either multiples or fractions of 1 D.

11. The focal length of a lens, and the power required in a lens to produce a certain focal length, may be estimated by dividing ~~40~~ 100 by either. Thus a lens of 4 D. has its focus at

25 cm., and it therefore follows that a 25 cm. focus requires a lens of 4 D.

Lens Scale.

Dioptres.	cm.	Dioptres.	cm.	Dioptres.	cm.	Dioptres.	cm.
·25	400	2·25	43	5·	20	11·	9
·50	200	2·50	40	5·50	17	12·	8
·75	130	2·75	35	6·	16	13·	7½
1·	100	3·	33	6·50	15½	14·	7
1·25	77	3·25	30	7·	15	15·	6½
1·50	65	3·50	27	8·	12½	16·	6
1·75	55	4·	25	9·	11	18·	5½
2·	50	4·50	22½	10·	10	20·	5

II. Analysis and Neutralisation of Lenses.

12. Objects viewed through a moving convex lens appear to move in the opposite direction to the lens ; viewed through a moving concave lens, appear to move in the same direction ; and viewed through a moving prism show no movement unless the prism be rotated, but straight lines will be seen to be broken, and the break will be in the opposite direction to the base of the prism.

13. A spherical lens of either power will be recognised by the apparent movement of the

object being the same in every meridian; a sphero-cylinder, by the movement in one meridian, being more pronounced than in another; and a simple cylinder, by the movement being in only one meridian—the axis meridian having no focus.

14. Lenses are neutralised by opposite powers of the same degree, and this is best effected by sphericals. To neutralise a simple cylinder, find the spherical lens which neutralises in the opposite meridian to the axis. Then prove with the cylinder. To neutralise a sphero-cylinder, find the spherical lens which neutralises in one meridian, then do the same for the other. The cylindrical part of the combination is denoted by the difference in strength of the two sphericals, the spherical part being the weaker of the two sphericals; thus, if in the horizontal meridian we find sph. + 0·5, and in the vertical meridian sph. + 1·0, the prescription would be, sph. + 0·5 $\overset{\frown}{\smile}$ cyl. + 0·5, ax. h. Then prove with the spheric and the cylinder.

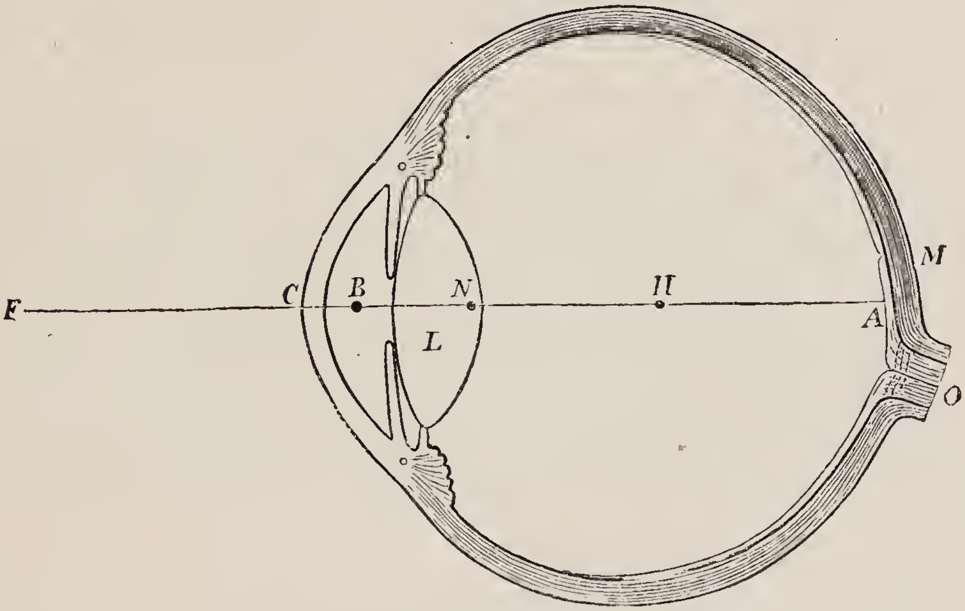
15. In prism combinations the spherical and cylindrical lenses must be first discovered, when the degree of the prism can be found by placing the lens and its neutralising refractive

element together, and looking through them at the prism scale (Fig. xii.).

III. The Refractive or Dioptric System.

16. This system is a compound one, made up of a spherical surface and a bi-convex lens, together being equal to about 23 mm. focus. It consists of three refracting surfaces—the anterior surfaces of the cornea, the lens, and the vitreous respectively; and three refracting media—the *aqueous*, the *lens*, and the *vitreous*.

Fig. ii.



(From Hartridge.*)

17. There are six cardinal points of the eye: two *principal points*, two *nodal points*, and two *principal foci*, all situated at the optic axis (21).

---

* 'Refraction of the Eye.'

18. The two *principal points* (Fig. ii. *B*) are situated close together in the middle of the corneal chamber, about 2 mm. behind the cornea. For all practical purposes they may be considered as one.

19. The two *nodal points* are situated close together, within the lens and close to its posterior surface (Fig. ii. *N*), about 7 mm. behind the cornea, and 15 mm. in front of the *macula* or yellow spot—the most sensitive part of the retina. They also may be considered as one.

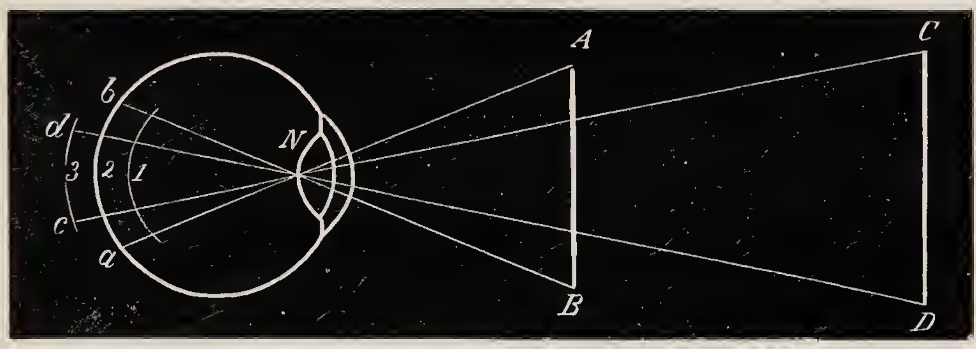
20. The *principal foci.*—The *first principal focus* (*F*) is situated about 13·7 mm. in front of the cornea, and is that point on the axis where rays, parallel in the vitreous, meet. The *second principal focus* is 22·8 mm. behind the cornea, and is the point on the axis where parallel rays meet after passing through the eye.

21. The *optic axis* (Fig. ii. *F A*) is the line passing through the centre of the cornea, the nodal point, and the centre of rotation (*H*) 9·8 mm. in front of the retina, to the inner side of the *macula* (*M*).

22. The *visual axis* is a line passing from the macula through the nodal point to the object looked at.

23. The *visual angle* (Fig. iii. CND) is the angle formed at the nodal point (N), being part of a triangle having its base at the object looked at (CD). The size of the angle depends upon the size and the distance of the object; thus: an object at AB, which is as large as one at CD, but nearer to the eye, will be seen under a larger

Fig. iii.

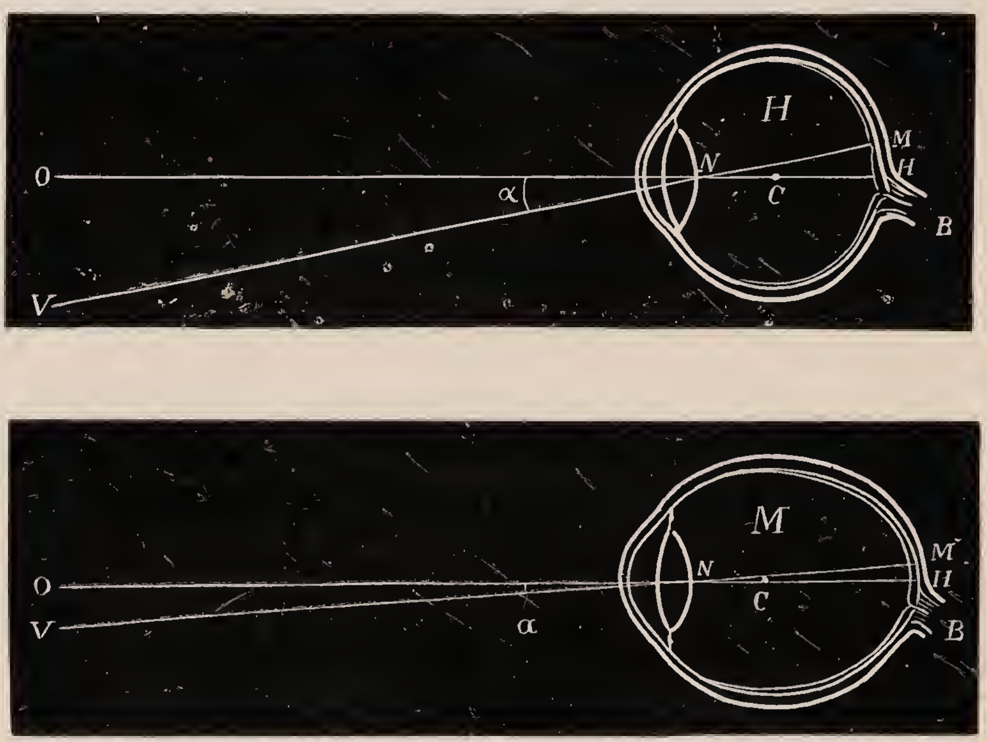


(From Hartridge.)

angle, the angle ANB being greater than the angle CND. The size of the image also, formed on the retina, will depend upon the antero-posterior diameter of the eyeball, it being smaller at 1, when this diameter is less, as in hypermetropia, than it is at 2, as in emmetropia, and larger than either at 3, as in myopia, when the eyeball is elongated. A patient may, therefore, be unable to read the smallest type and still have some defect of refraction, unless the type be read at its proper distance.

24. The *angle α*, of interest in strabismus, is the angle formed also at the nodal point, but by the crossing of the two axes, viz. the optic and the visual. In emmetropia (26) this angle is usually about 5°. In hypermetropia (Fig. iv. *H*), owing to the shortening of the antero-posterior diameter of the eyeball, and the divergence of the visual axes, it is greater. In myopia (Fig. iv. *M*) the angle is less, owing to the lengthen-

Fig. iv.



(From Hartridge.)

ing of the antero-posterior diameter and the convergence of the visual axes.

IV. Normal Vision and Accommodation.

25. For normal vision to exist it is necessary that the axial length of the eyeball and the focal length (8) should be the same. When there is the slightest want of harmony between these—either owing to the shape of the eyeball or the cornea, or to any defect in the accommodative apparatus, it is necessary for optical aid to step in.

26. By *accommodation* is meant the exercise of that involuntary power possessed by everyone whose refraction is normal, *i. e.* the emmetrope (ἐμ, within; μέτρον, measure; ὤψ, the eye), and which enables the subject to see objects between the p.p. or "near point" and the p.r. or "distant point" at infinity. It is the power of altering the focus, *i. e.* of unconsciously adapting the shape of the crystalline lens (intra-ocular), and the position of the axis of the eyeball (extra-ocular) to the varying conditions to which the eyeball is subject. When accommodation is defective and parallel rays are focussed behind or in front of the retina, the condition is termed *ametropia* (α, priv., μέτρον, measure).

27. For refraction to be normal, the parallel rays entering the eye through the pupil and passing through the refractive media (16) unite exactly on the retina at the second principal focus.

28. During accommodation, the convexity of the lens is altered by the action of the ciliary muscle, which contracting, draws forward the choroid, thereby relaxing the suspensory ligament and allowing the elasticity of the lens when looking at near objects, to come into play.

29. During distant vision the accommodative power is at repose, the optic axes being parallel or, more usually, slightly divergent, but immediately the visual axes are directed to a point nearer than infinity, extra-ocular accommodation (the internal recti muscles) acts in unison with intra-ocular accommodation (the ciliary muscle), and convergence is brought into use, by which the maculæ of both eyes are directed towards the same point, so that images received upon the retina of each eye are blended into one, and singleness of vision is produced. If any defect, or want of harmony in the association of the different parts of the accommodative apparatus —as, for instance, when the image is formed on parts of the retina which do not exactly

correspond in the two eyes—exists, *diplopia* διπλόος double, ὤψ the eye), and eventually *asthenopia*, results.

30. The p.p. is the nearest point of the range of accommodation at which objects can be seen distinctly. It recedes gradually as age advances. When it has receded beyond 22 cm., which it does about the age of forty-five, *presbyopia* occurs. The p.r. is at infinity. The space between the p.p. and the p.r. is termed the "range of accommodation"; and the force necessary to change the eye from its p.r. to its p.p. (irrespective of the refractive condition of the eye) is a fixed quantity, the same in emmetropes, hypermetropes, and myopes, and is termed the "amplitude of accommodation."

31. *Range of accommodation.*

At age.		p.p.	Most comfortable reading point.
10	14 D.	7 cm.	11 cm.
15	12 ,,	8·5 ,,	12½ ,,
20	10 ,,	10 ,,	14 ,,
30	7 ,,	14 ,,	20 ,,
40	4·5 ,,	22 ,,	33 ,,
50	2·5 ,,	40 ,,	60 ,,
60	1 ,,	100	
75	0		

32. The p.p. in an emmetrope, aged forty, is 22 cm. An emmetrope, aged twenty, has + 10 D. of amplitude of accommodation (10). He can accommodate to the extent of + 4·5 D. when reading at a distance of 22 cm. If he is hypermetropic to the extent of 4·5 D., in order to read at 22 cm. (9 in.), he would have to double his accommodative effort to overcome the defect, *i. e.* he would have to bring into play 9 D. out of his total of 10 D.

V. Asthenopia.

33. *Asthenopia* (ἀσθενής weak, ὤψ eye), or eye strain may be accommodative or muscular. *Accommodative asthenopia*, or fatigue of the ciliary muscle, is generally associated with hypermetropia or hypermetropic astigmatism, less frequently, with myopia. In the former cases, it is due to the excessive use of that muscle where errors of refraction exist uncorrected, and hypertrophy of the ciliary occurs. The overstrain may produce tonic spasm, when myopia is simulated.

34. *Muscular asthenopia*, or fatigue of the extra-ocular muscles producing latent imbalance or disturbance of equilibrium (*hetero-*

phoria), is most common in adults, but may occur in children during the educational period. When the muscular imbalance exceeds a certain degree, as is the case in converging and diverging strabismus, *diplopia* is the result. Normally the two eyes are in a state of perfect equilibrium (*orthophoria*), the adjustment being so fine as to allow of the images of objects appearing exactly on the same spot of each retina.

35. The *symptoms of asthenopia.*—Headache, and acute pain in the eyes or orbits; the more acute it is, the more does it point to asthenopia. The pain is increased when the eyes are used for near objects, but sometimes there is no pain, and at others it is referred to the back of the neck; the type becomes indistinct or double and blurred, and the patient rubs his eyes. There is photophobia, lacrimation, and more or less conjunctival congestion with blinking of the eyelids, which become red and irritable. The symptoms are always accentuated after a day's work, especially if artificial light has been used. In children headache comes on shortly after commencing school work accompanied by blinking of the eyelids.

VI. HETEROPHORIA.

36. Heterophoria (ἕτερος different, φορεω I bear) or muscular imbalance may manifest itself in either eye as *esophoria* or latent convergence, *exophoria* or latent divergence, or *hyperphoria* or latent deviation upwards. They are all forms of muscular asthenopia.

37. *Esophoria*, usually associated with, and often caused by hypermetropia (frequently latent) is seldom met with according to Hartridge, though common, as it quickly passes on to convergent strabismus.

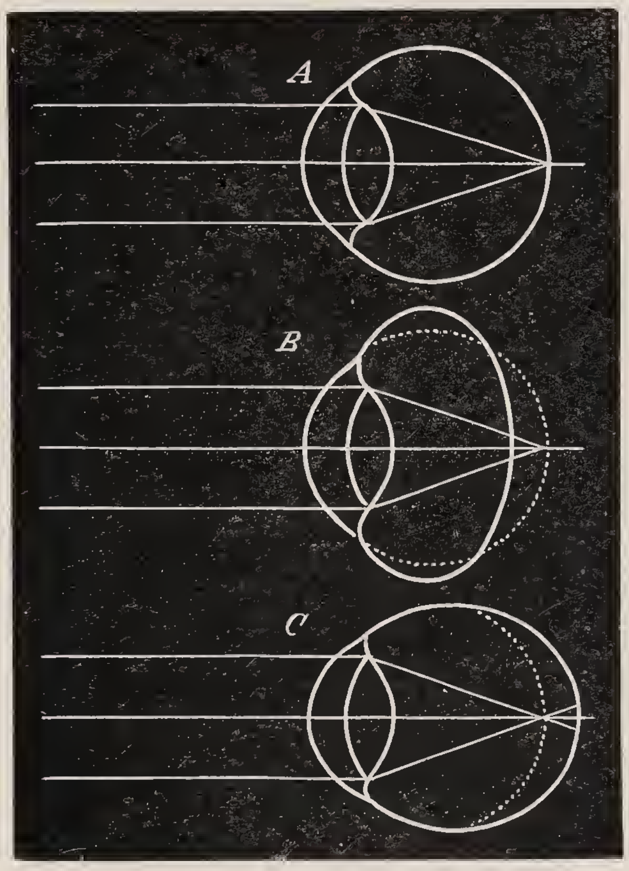
38. *Exophoria*, the commonest of these defects, is most frequently associated with myopia. The tendency of the eye to turn outwards is caused by inability to maintain the prolonged convergence necessary to perfect vision, from insufficiency of the internal recti muscles.

39. *Hyperphoria*, or latent deviation upwards of one eye, is caused by insufficiency of the oblique muscles. It is usually associated with esophoria, but may exist alone. It is a common defect.

40. The *symptoms of heterophoria* are those of asthenopia in general. Want of harmony between the functions of convergence and

accommodation is a frequent source of headache, and if it persists after application to near work, when the visual acuteness is normal, heterophoria may reasonably be suspected.

Fig. v.



A. Emmetropic eye. B. Hypermetropic eye. C. Myopic eye.
(From Hartridge.)

VII. HYPERMETROPIA.

41. All eyes at birth are hypermetropic (ὑπέρ above, μέτρον measure, ὤψ eye), the ocular development being incomplete until the age of puberty; hypermetropia is therefore more common than myopia. In hypermetropia this

natural development has been arrested, with the result that the axial length (of the eyeball) is less than the focal length (of vision); in other words the eyeball is too short, the parallel rays of light being brought to a focus behind the retina (Fig. iii. 3). The higher the degree of hypermetropia, the further from the eye is the p.r.

42. Hypermetropic children should not be allowed to use their eyes for near sight till proper correcting glasses can be used with safety, *i. e.* at the age of four or five years. As some diminution in degree may be looked for, the sight should be tested every two or three years, with a view to reducing the strength of the lenses. But after adult life is reached no change is likely to occur, though the defect will not be likely to increase.

43. In young hypermetropes there is frequently a certain amount of *latent* hypermetropia hidden behind the strong accommodative effort which can only be discovered under atropine. And if—where atropine has not been used—the hypermetropia is found only to be partially corrected, that the above exists may be looked upon as a certainty.

44. The *symptoms of hypermetropia.*—Distant

vision is good. There is difficulty in reading long together, especially in the evening. After reading for some time the type becomes indistinct, and the eyes ache. Headache, nausea, and sometimes vomiting, all of which symptoms pass off after a night's rest. Hypermetropes usually have small eyes and pupils.

45. In prescribing glasses for reading in hypermetropia, it is advisable to fully correct the *manifest* hypermetropia whilst giving one third only of the correction for the *latent* hypermetropia discovered under atropine.

46. In young persons whose hypermetropia does not exceed 3 or 4 D., and distant vision is good without glasses, these need only be worn for reading or near work. But when this is exceeded or when hypermetropia is complicated with convergent concomitant strabismus, glasses should be worn constantly.

47. A hypermetrope of over forty years of age will be presbyopic also. The reading test must therefore be applied. The correction for the distant vision only (the hypermetropia) should be worn constantly.

48. In hypermetropes the ciliary muscle becomes hypertrophied owing to its excessive use, thus overcrowding the ciliary region, with

the consequence that *glaucoma* is most common in hypermetropic eyes.

49. Where atropine is not used, and especially in the young, with whom the accommodative effort is very strong, hypermetropes will sometimes, owing to ciliary spasm, prefer a concave to a convex lens, the explanation being that the concave lens exercises a stimulative effect on accommodation, producing a temporary false myopia.

VIII. Myopia.

50. In myopia (μύω I close, ὤψ the eye) the axial length is greater than the focal length—in other words, the eyeball is too long, with the result that the parallel rays are brought to a focus in front of the retina (Fig. v. *c*). In order to see near objects the eyes must converge, with the result that, when reading, the book is held close to the eyes; and if this convergence be not counteracted ultimate blindness may ensue.

51. Myopia is seldom or never congenital, but shows itself generally about the eighth year. The earlier it appears the greater the tendency to increase and the more serious it is, and when corrected there is no certainty that

the defect will not increase. When it shows itself after school life the tendency to increase is not so great, but when it increases after adult life it is very serious and is then termed *progressive myopia.*

52. Myopia is the most serious of all errors of refraction. In the higher degrees (above 6 D.) pathological changes are apt to occur in the eye which frequently end in destruction of vision. The backward compression of the globe by the extra-ocular muscles, produced in the instinctive endeavour by the patient to improve the distant vision by cutting off the divergent rays, and by excessive convergence which is resorted to for near work, is apt to produce atrophy of the choroid. Myopes, however, enjoy an almost complete immunity from *glaucoma* because of the atrophy of the ciliary muscle due to the comparative lack of its use.

53. The *symptoms of myopia.*—Distant vision is defective, but there is no discomfort with near work, though the object is held nearer than normal. Vision at night is bad. Sparks, circles, flashes of light, etc., may be seen. Straight lines appear bent or broken. There is nearly always *photophobia.* Headache is unusual, and the eyes and pupils are usually

large. In low degrees, and when uncomplicated with astigmatism, there is no *asthenopia*. And when the presbyopic period is reached the myopia is neutralised by the *presbyopia*, and the patient is able to read without glasses.

54. A cycloplegic is always advisable in the young in case the defect from spasm of the accommodation might appear greater than it really is, and thus the full correction be exceeded. Where it is not used the defect must be under-corrected. Over-correction in all cases of myopia is to be avoided.

55. Glasses are absolutely necessary, not only for near vision for the purpose of compelling the patient to read farther away, but also for distant vision. Where examination of the distant vision indicates a low degree of myopia, spasm of the ciliary may be suspected, when retinoscopy should be practised before any glasses are ordered, and if a myopic shadow be found the patient should be atropised and re-examined.

56. The reading distance for a myope should be about 35 cm. (14 in.). For those whose distant vision is — 4 D. and upwards, two thirds less power in the concave lens should be provided for reading. As the lenses of the

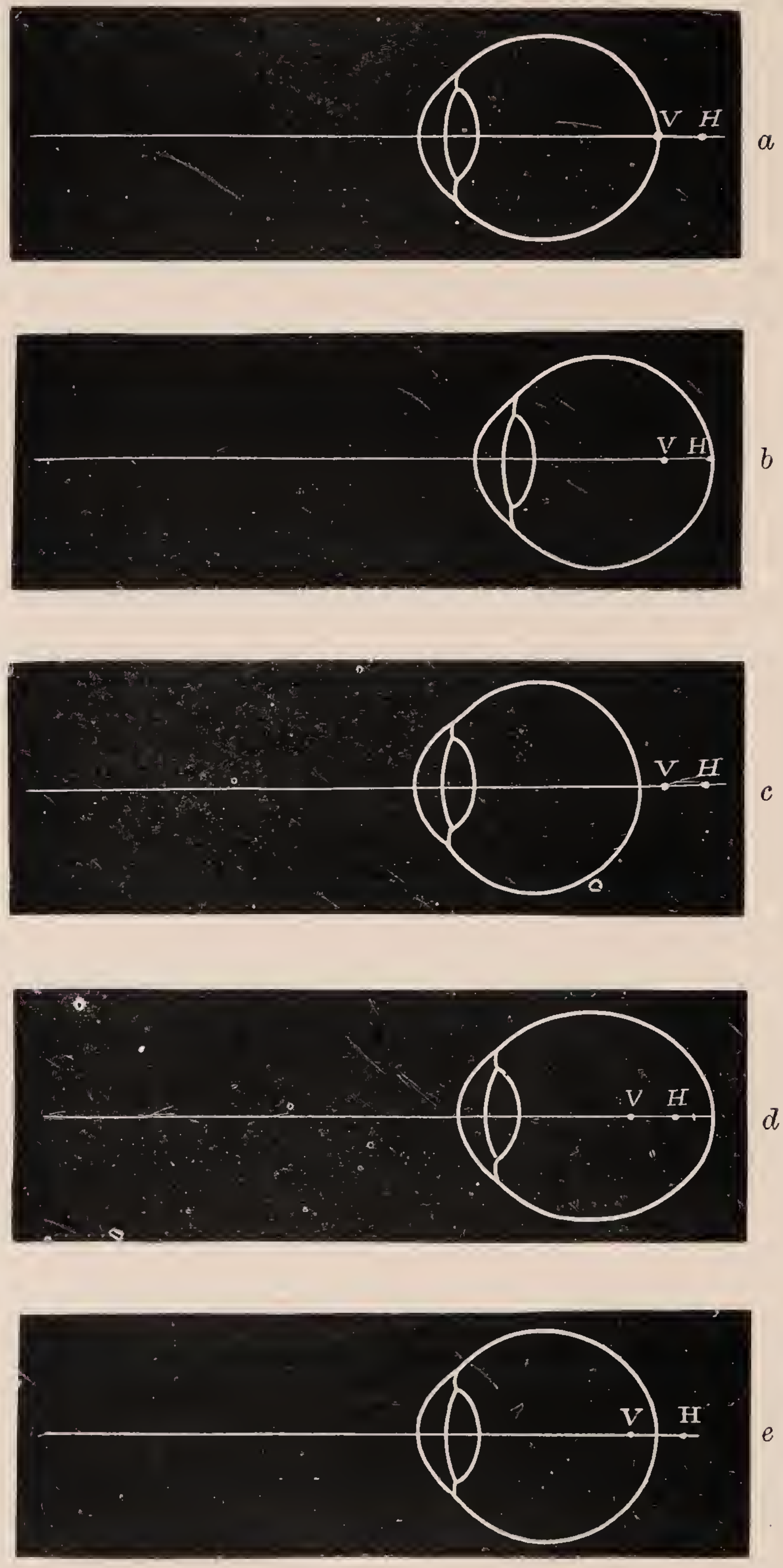
glasses will be worn nearer the eye than are those in the trial frame, they should be about ½ D. less in power for every 5 D. of myopia. A myope of 3 D. will not require glasses for reading, as his p.r. is at 33 cm. (13 in.). If he has 6 D. of myopia he will require − 3 D. in order to put back his p.r. from 16 cm. (6½ in.) to 33 cm. The higher the myopia the nearer to the eye is the p.r.; but the p.p. is determined by the amount of accommodation.

57. In *progressive myopia*, if the myopia increases rapidly with irritation, complete rest must be given to the eyes, and solution of atropine (gr. j–℥j) be dropped between the lids three times a day for two or three weeks; counter-irritation may also be applied to the temples or behind the ears. No glasses should be worn except smoke-coloured protectors. Reading should not be allowed until the irritation has subsided, and then only for a short time in a good light, the eyes still being atropised.

IX. Astigmatism.

58. In astigmatism (α not, στίγμα point) there is a difference in the refraction of the different meridians of the same eye, owing to the devia-

Fig. vi.



(From Hartridge.)

tion from the normal curvature of the dioptric surface. The fault may be either (1) at the lens, or (2) at the cornea; and may be *congenital*—when the defect is generally symmetrical in both eyes, or *acquired.* (1) When the fault is at the lens it is nearly always congenital; but this organ may be dislocated, when it is acquired. (2) When the fault is at the cornea—which is generally the case—it may be due, congenitally, to unequal shape or to conical cornea; pathologically, to *nebula;* and when acquired, to wounds or ulceration.

59. Astigmatism exists to some extent in nearly all eyes, but if only to such a small extent as not to disturb vision does not require optical aid.

60. *Regular astigmatism* (Fig. vi.) consists of (1) *simple*, wherein one meridian is defective, either hypermetropic (*a*) or myopic (*b*), the former being the most common ; (2) *compound* where both meridians are defective, either hypermetropic (*c*) or myopic (*d*), but in different degrees ; (3) *mixed* (*e*), where both meridians are defective—one hypermetropic, and the other myopic.

61. The *symptoms of astigmatism* are those of asthenopia in general. The head is fre-

quently noticed to be held on one side when an object is looked at, with the nose away from the object. In mixed astigmatism the patient usually has a vacant look, and screws up his eyes when looking at an object.

62. There are two principal meridians in astigmatism always at right angles to each other. They are the meridians of *greatest* and *least defect* (G.D. and L.D.). The meridian in which the patient sees best with the *strongest convex* lens is that in which he sees worst with the naked eye; it is therefore the meridian of greatest defect. The meridian in which he sees best with the *weakest concave* lens is that in which he sees best with the naked eye, and is the meridian of least defect. It is upon the discovery of the meridians of G.D. in hypermetropia, and of the L.D. in myopia, that the accuracy of our diagnosis, and correction, depends.

63. It must be understood that the meridians are always those of the card or dial, and not of the eye. Glasses are adjusted according to the former, which are the opposite to what the meridians of the eye would be found to be under an objective test such as *retinoscopy*.

64. In describing the meridian in which the

greatest refractive defect is found and in which the axis of a cylindrical lens is to be placed, the degrees of half a circle, *i. e.*, from 1° to 180°, are used, these being alone necessary, for the meridian of 1° is the same for purposes of refraction as 181° (see Fig. viii.). The horizontal and vertical meridians, 0° and 90°, are described as *h* and *v* respectively, and not by the number of the degree. These meridians are by some represented by a horizontal or vertical arrow, instead of by the abbreviations *Ax. h.* or *Ax. v.*

65. The greatest curvature and consequently the greatest refraction in the astigmatic eye, as in the normal eye, is usually in the vertical meridian; the least in the horizontal meridian. But there are exceptions to this, and when these exist the astigmatism is said to be "against the rule." In all forms of astigmatism, the horizontal meridian is generally the hypermetropic one, and the vertical the myopic one; consequently, in hypermetropic astigmatism the axis of the correcting cylinder is generally required to be placed vertically, and in myopic astigmatism, horizontally. In simple hypermetropic astigmatism the vertical meridian is emmetropic.

66. On wearing suitable glasses improvement is not always at first perceptible, especially in mixed astigmatism (though generally at once apparent in hypermetropic astigmatism); in fact, for the first two or three weeks the glasses may be worn only by an effort, and may even increase the discomfort until the eye becomes accustomed to them.

67. *Irregular astigmatism* exists where the curvature in any single meridian is not everywhere alike, so that the rays passing through the same meridian are never united in one point. When congenital the lens is usually in fault (*incipient cataract*); when pathological, it is usually the cornea (*conical cornea* or *ulceration*). This condition cannot be corrected by glasses.

68. *The stenopaic slit* is a dischaving a narrow, oblong opening in it, and may be found useful in diagnosing cases of astigmatism. It is rotated in the trial frame while the patient looks steadily at the distant type, and the meridian in which the best vision obtained noted. We then try the defective meridian, first with spherical convex, and then with concave lenses placed in front of the disc. Example: Supposing, with the slit in the vertical meridian, vision is $\frac{6}{6}$, but with convex

lenses is indistinct, the vertical meridian is emmetropic. Place it in the opposite meridian—the horizontal—and vision is found to be $\frac{6}{12}$, but with sph. + 2·0 vision is $\frac{6}{6}$, the horizontal meridian is hypermetropic, the case being one of simple hypermetropic astigmatism, requiring for correction cyl. + 2, ax. v.

X. PRESBYOPIA.

69. Presbyopia (πρεσβυς old, ὤψ eye) is caused by loss of elasticity in, and the power which it possesses of increasing the convexity of, the lens, and to some extent to loss of power in the ciliary muscle, with consequent recession of the p.p. The lens gradually increases in size and approaches the cornea, becoming somewhat flatter. The result is that near objects are not seen so clearly as formerly, the p.p. being farther away, and receding as age advances.

70. *Symptoms of presbyopia.*—Gradually increasing sense of fatigue, due to presbyopic asthenia, after reading; and a feeling as if there were not light enough.

71. Presbyopia generally manifests itself at forty-five years of age or thereabouts, when the p.p. has receded beyond the distance at which we are accustomed to read or write with comfort

(22 cm.); in hypermetropia, earlier; in myopia, later. At the age of forty the eye of the emmetrope possesses just that amount of refractive power which enables him to see at 22 cm.

72. The lenses for presbyopia ought to give distinct vision only, and not magnify; they also ought first to be used only by artificial or insufficient light for very fine work.

Presbyopia with Hypermetropia.

73. Hypermetropes generally are more presbyopic than emmetropes at the same age, and therefore require stronger lenses.

74. The lenses which correct the hypermetropia only should be worn constantly, the presbyopic correction, for reading only.

Presbyopia with Myopia.

75. Owing to the gradual recession of the p.p. with advancing age, in myopia it will be longer in reaching the point (22 cm.) when presbyopia commences than in the emmetrope, so that in prescribing glasses for presbyopes the amount of myopia has to be deducted from the lens which the emmetrope would require at any given age.

76. Myopia depends upon the p.r., while presbyopia depends upon the p.p.

77. It is only when the p.p. has receded beyond 36 to 38 cm. that myopes may require convex lenses for reading.

78. A myope of 1 D. at age 50, will, according to the presbyopic scale (145), have a presbyopia of 1 D.; consequently one will neutralise the other, and he will require no glasses.

79. It is only myopes under 3 D., whose p.r. is more than 33 cm. away, who may require convex lenses for reading while still requiring concave lenses for distance, and then only late in life. A myope of 2·5 D. has his p.r. at 40·5 cm.; one of 2 D. at 51 cm.; one of 1·5 D. at 76 cm.; and as these two last are not comfortable distances for reading, convex glasses become necessary.

XI. Strabismus.

(*Although strabismus does not come within the scope of subjective sight-testing, a few notes on the subject may not be unacceptable to the reader.*)

80. Strabismus (στραβισμός, squinting) exists where, owing to the disturbed muscular equilibrium of one eye, the deviation in its direction

is such that the visual axes of the two eyes are not directed to the same object, with the result that the image of the object is not received by the maculæ of both eyes, and binocular vision is rendered impossible. It may be due to defective anatomical conditions, or—which is more common—to abnormal innervation, causing contraction of the extra-ocular muscles, and so excessive convergence or divergence.

81. *To diagnose the squint.*—Hold the finger up about a yard in front of the patient, and direct him to fix his eyes upon it. Then gradually approach him with the finger, so as to call into action his accommodation. (*a*) If both eyes steadily follow the finger there can be no squint, and it is only *apparent.* (*b*) If one eye follows the finger, while the other, after following it up to a certain distance, suddenly deviates inwards or outwards, *concomitant strabismus*, convergent or divergent, is diagnosed. But the squinting eye follows the fixing (non-squinting) one in all its movements, the visual axes maintaining the same relation to each other in whichever direction the eyes are turned. (*c*) If both eyes follow the finger up to a certain point, where one eye stops "after making a few jerking, oscillatory movements,"

move the finger up and down and from side to side about 45 cm. from the patient. If the squinting eye stops at a certain point, while the other (the fixing) eye continues to follow the finger, *paralytic strabismus* is diagnosed. The movements of the squinting eye in this variety are usually very limited. There is always *diplopia* in this variety, but seldom in the concomitant variety, because the false image seen by the squinting eye gradually becomes suppressed.

Concomitant Strabismus.

82. In concomitant strabismus one eye is generally directed inwards—*convergent*, or outwards—*divergent*, but sometimes these are combined with a slight upward or downward tendency. The former is the most common form.

83. Squint is not present at birth and never exists in both eyes at once. It generally makes its appearance about the fourth or fifth year, as soon, in fact, as the child begins to look at near objects, and is generally convergent.

84. In infancy, before the brain centres and

the vision faculty are sufficiently developed—before the seventh or eighth month; and whilst the eyes are being educated for binocular vision, they are normally liable to independent movement and thus to singleness of vision. And this tendency is aggravated by teething and other disturbances of the general health. Infantile squinting, however, disappears in the majority of cases. But if, after arriving at a year old, the squinting still persists it is abnormal, and should receive immediate attention. If neglected, the squinting eye, being but little used, will become *amblyopic* (ἀμβλυς, dull) in time—the first stage of *amaurosis* (ἀμαυρὸς, obscure).

85. Squinting may be *alternating*—when sometimes one eye becomes the fixing one and sometimes the other, indiscriminately; *constant*—when the same eye always squints; or *periodic*—when the squinting eye only deviates occasionally. The last form may with careful treatment be cured without an operation; if neglected, it generally lapses into the constant form.

86. In *convergent strabismus* the image is received on the inner side of the macula of the squinting eye, and the image is projected

to the *temporal* side of the real object. In *divergent strabismus* the image falls on the *temporal* side of the macula, and is projected to the *nasal* side of the object. In the upward variety the false image is projected *below*, and in the downward variety, *above*.

87. The greater the deviation of the eye the further apart are the images, and the less distinct the false image.

88. *Convergent strabismus* is intimately connected with, and usually caused by, hypermetropia. The convergence exceeds the accommodation, and is most marked when looking at near objects. In high degrees of hypermetropia when no amount of accommodation can make vision distinct, squint is less likely to occur. It is usually, therefore, in cases of from 2 D. to 4 D. that convergent squint is most frequently met with.

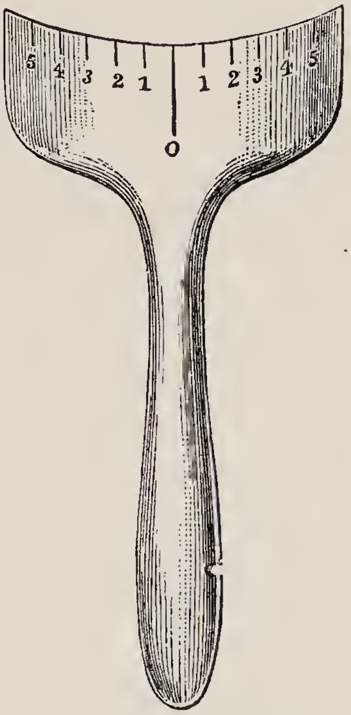
89. *Divergent strabismus* is not so common as the convergent variety. It is usually due to myopia, in which condition the extreme convergence necessary to enable the patient to see objects within the range of his far point produces an asthenopic condition of the internal rectus, which, becoming fatigued, gives way, and the eye deviates outwards.

90. *To estimate the degree of the squint.*—The usual method is to make an ink mark on the lower eyelids of both eyes immediately below the centres of the pupils. Hold a card in front of the fixing eye, when the squinting eye will at once make a movement outwards or inwards, as the case may be, to fix the object; a second mark is then made as before below the squinting eye in its new position. The difference between the two marks represents the amount of the squint. This is called the *primary deviation.* But while the squinting eye was deviating to fix the object, the fixing eye behind the card will also have deviated in the same direction as the squinting eye. This is the *secondary deviation.* And a second mark is now made below this eye in its new position, when the deviation will be found to equal exactly that in the squinting eye, which is a characteristic of concomitant squint, whereas in paralytic squint the secondary deviation exceeds the primary.

91. The deviations represented by the ink-marks are now measured with the strabismometer (Fig. vii.), which is placed below the lower eyelid, when the degree of the deviation can be read off. If great exactness be

required the perimeter may be used, by which the angle of the squint (*i. e.* the angle which the visual axis makes with the direction it should take normally) may be measured.

Fig. vii.



Strabismometer.

92. *Treatment.*—Young children should be discouraged as much as possible from looking at near objects. Any error of refraction is to be corrected to prevent excessive accommodation, and equalise the two functions of accommodation and convergence. In slight cases, if the squint disappears under atropine, glasses will probably effect a cure, but they

must be worn for some months. Tying up the fixing eye for an hour or so a day is found useful. Mr. Hartridge recommends the application of 1 drop of a ½ per cent. solution of atropine to the fixing eye twice a week to prevent this eye being used for near objects, and to compel the deviating eye to be employed for this purpose; and says that "in periodic strabismus, where squinting has only just commenced, and arises only under the influence of excessive accommodation necessary to enable the child to see near objects, this treatment may at once correct the deviation." Glasses may then only be necessary for constant use for a year or two, but must be continued for near work for a much longer time.

93. When the squint has become permanent, glasses may have to be worn constantly for many years.

94. In children under three years of age glasses should rarely be ordered, owing to the difficulty and danger attending their use.

95. When normal vision is not obtained after correction, muscular exercises must be adopted, and the development and cultivation of the vision faculty carried out by stereoscopes or Worth's amblyoscope.

96. If, after glasses have been worn for some months, no improvement is manifested, operative interference will be necessary, though not, as a rule, before seven years of age.

97. All cases of strabismus over one year of age should be examined objectively by retinoscopy under atropine, in order that the refractive condition may be accurately estimated, and the proper correcting glasses supplied for constant use.

98. In divergent squint with myopia, the full correction should be given for constant use. But "when divergent squint is developed, the only successful treatment is operation" (Jessop).

PART II

SUBJECTIVE SIGHT TESTING.

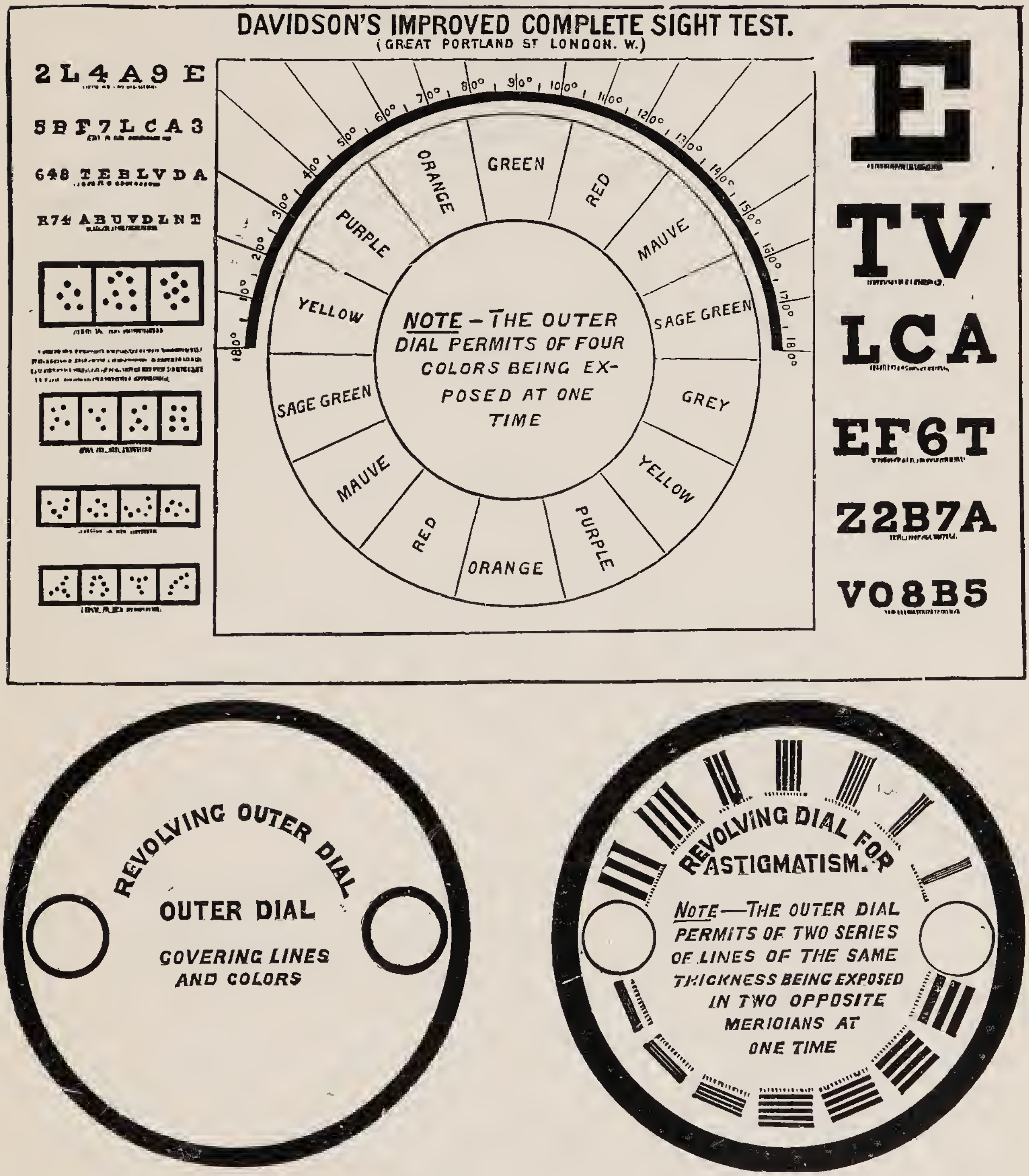
XII. Preliminary Notes.

(*General.*)

99. The student should provide himself with a complete set of trial lenses, consisting of two sets each of the following: Convex and concave sphericals, from ·25 to 4·0 in quarters, from 4·0 to 6·5 in halves, and from 7·0 to 10·0 in complete dioptres. Convex and concave cylindricals from ·25, in quarters to 4·0. One set of ten prisms, pin-hole disc, stenopaic slit, Maddox rods in reversible frame, and adjustable trial frame. Also a metric measure, and a sight test card similar to that shown in Fig. viii, revolving in the centre of which are two circular dials. The card should be hung so that the centre is as nearly as possible on a level with the patient's eyes, and should be provided with a good light. The inner dial has groups of lines of various thicknesses on it, arranged in such a manner that in whichever way it is

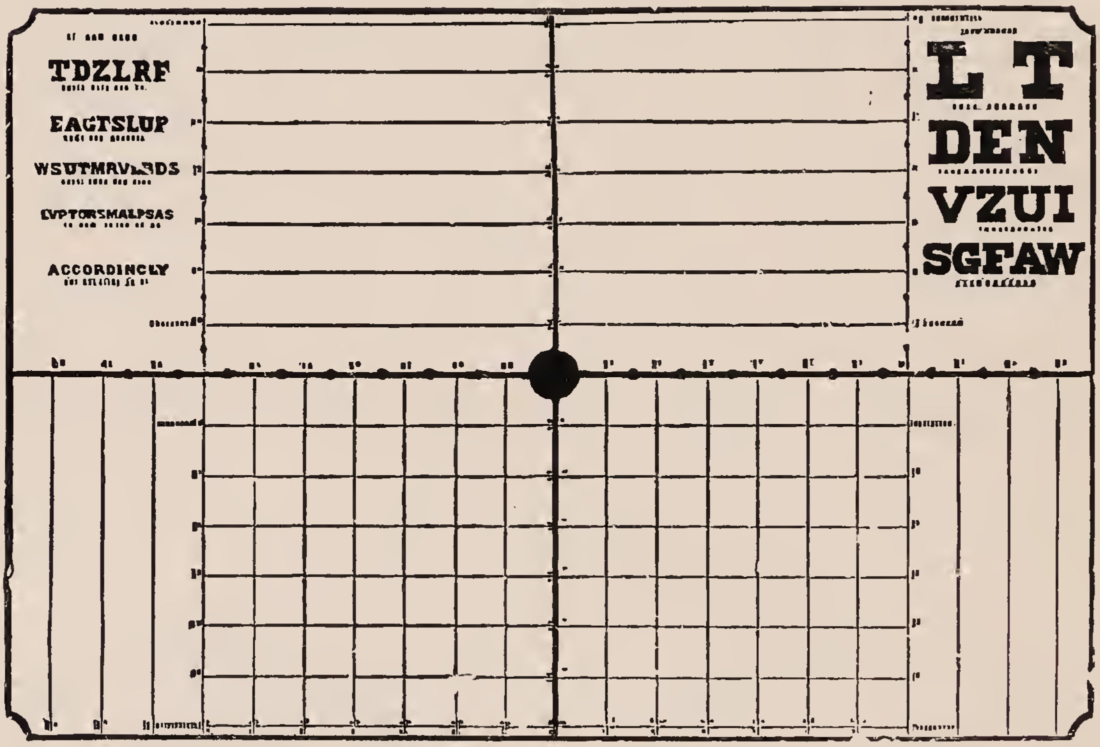
turned, there are always two groups of the same size exposed, opposite, and at right

Fig. viii.


DAVIDSON'S IMPROVED COMPLETE SIGHT TEST.
(GREAT PORTLAND ST LONDON. W.)
2 L 4 A 9 E
5 B F 7 L C A 3
648 T E B L V D A
R74 A B U V D L N T
10° 20° 30° 40° 50° 60° 70° 80° 90° 100° 110° 120° 130° 140° 150° 160° 170° 180°
ORANGE
GREEN
RED
PURPLE
MAUVE
YELLOW
SAGE GREEN
GREY
YELLOW
PURPLE
ORANGE
RED
MAUVE
SAGE GREEN
NOTE – THE OUTER DIAL PERMITS OF FOUR COLORS BEING EXPOSED AT ONE TIME
E
TV
LCA
EF6T
Z2B7A
VO8B5
REVOLVING OUTER DIAL
OUTER DIAL
COVERING LINES AND COLORS
REVOLVING DIAL FOR ASTIGMATISM.
NOTE—THE OUTER DIAL PERMITS OF TWO SERIES OF LINES OF THE SAME THICKNESS BEING EXPOSED IN TWO OPPOSITE MERIDIANS AT ONE TIME

angles to each other. Under each set of lines is marked the distance in metres and feet at which the normal eye can count them. The outer dial has two openings that allow of only two sets of lines being exposed at one time. The radiating lines around the semicircle on the main card denote the meridians at which the lines are exposed. On each side of the main card are test letters and figures of various signs, according to Snellen, and the dot tests for recruits. The reverse side of the card (Fig. ix.) is arranged for testing defects of the ocular muscles (*heterophoria*), and for using with the Maddox multiple rods and prisms.

Fig. ix.



100. To use the dial and lines, find the meri-

dian in which the smallest lines, or those normal for distance, are best counted, and then rotate dial forty-five degrees above and below it, to find if they can be counted better in any intermediate meridian.

101. Each eye should be examined separately, the opposite eye-piece of the trial spectacle frame being closed during the examination.

102. The distant vision should be first tested, then the near, and the muscular condition last. The patient is placed at least 3 metres (10 ft.) from the card, but 4·5 m. (15 ft.) is better, and 6 m. (20 ft.) is better still. The largest type should be read at 60 m. (200 ft.), the rest as marked under each: 36, 24, 18, 15, 12, 9, 6 (20 ft.), 4·5 (15 ft.), and 3 m. (10 ft.).

103. Normal vision is described as being $\frac{6}{6}$, the upper figure or numerator representing the distance in metres at which letters can be read from; the lower figure or denominator representing the distance the smallest letters which can be read, should be read from. For instance, the letters which should be read at 6 m. cannot be read at that distance, but those which should be read at 9 or 12 m. can be read. Vision is then said to be $\frac{6}{9}$ or $\frac{6}{12}$.

104. If vision = $\frac{6}{6}$ and a cylinder makes it

worse in every meridian, normal vision is confirmed.

105. Examination should always commence with + lenses, and every meridian tested, before using – lenses. Stronger convex lenses (about 0·50 is generally enough), and weaker concave lenses should be used for *lines* than for *letters*, but only for that purpose, and are subsequently discarded.

106. In hypermetropic conditions the *strongest* convex lens, and in myopic conditions, the *weakest* concave lens, giving good vision should be used (45). In myopic conditions the use of convex lenses in every meridian should be exhausted before using concave lenses. When a cycloplegic is used, allowance must be made accordingly. The correction in hypermetropia must be slightly reduced (by, say, + 1 D.), and in myopia by slightly increasing it.

107. The fact of lines being seen in any one meridian better than in another, or the lines of letters which run in one direction better than those which run in another, is proof of the existence of astigmatism.

108. If improvement results in any one meridian with convex sphericals, it is a proof of hypermetropic astigmatism in that meridian.

109. When testing for astigmatism, spherical lenses should be used for *lines*, and cylindrical lenses for *letters*. And stronger + lenses, and weaker – lenses used for *lines* than for *letters*.

110. In compound astigmatism the spherical lens required is that which corrects the weakest meridian; the cylindrical lens, that which corrects the opposite; and the power of the latter, and the degree of astigmatism is equivalent to the difference between the two meridians. In mixed astigmatism the degree of astigmatism is the sum of both meridians.

111. The axis of the cylindrical lens should always be placed in the meridian of G.D. *of the dial*. In placing the axis in this meridian, we really place it in the meridian of L.D. *of the eye*.

(*The Pin-hole Disc.*)

112. If both near and distant vision be defective, the pin-hole disc will at once enable us to decide whether the fault is refractive or not. The minute hole in the centre should be placed in front of the centre of the pupil. If there be improvement the defect is refractive, and astigmatism may be suspected; but if there be no improvement it is either the transparent media or the retinal sensibility that is in fault.

(*Cycloplegics.*)

113. Cycloplegics (κύκλος circle, πληγή stroke) produces paralysis of the ciliary muscles and of accommodation, and dilatation of the pupil.

114. The two cycloplegics in general use in estimating errors of refraction are *atropine* and *homatropine.* The former is generally used for all young people ; the latter for adults, in whom only a modified effect is required, for owing to the length of time—about a week—during which the effects of atropine continue, few could put up with the inconvenience caused by it. In any case *atropine* should never be used for patients *over thirty-five years of age.* Homatropine is always safer.

115. For subjective examination it is advisable, and for objective examination (retinoscopy) it is absolutely necessary to use a cycloplegic for astigmats, young squinters, and myopes *under sixteen,* also for hypermetropes under twenty, in order to make sure of completely paralysing accommodation, and of allaying any spasm of the ciliary muscle.

116. A cycloplegic is seldom required for patients *over twenty-five years of age,* owing to the declining power of accommodation, but may be required up to forty-five years in those

with whom correction without homatropine has failed to relieve the asthenopia.

117. Owing to the risk of inducing glaucoma in patients over thirty by the use of a cycloplegic, care should be taken to previously estimate the tension of the eyeball.

118. The cycloplegic may be applied to the inner surface of each lower eyelid, either in the form of lamellæ or in solution.

Under fifteen years of age.—One drop of the following solution, or one lamella, twice a day for three or four days previous to examination. In children, Mr. Hartridge recommends the continuance of the atropine till the spectacles are ready for use:

℞ *Atropini hydrobrom.* or *sulph.*
Cocain. hydrochlorid. āā 0·16 gm.
Aq. distil. ad 30 ml.
or *Lamella. atropin. hydrobrom.* and
Cocain. hydrochlor. āā 0·0003 gm.

Over fifteen years of age.—One drop of the following solution, or one lamella, an hour before examination, and repeated in twenty minutes, when the patient is under twenty-five years of age: when over that age, one application an hour previous will be sufficient. Cocaine not only increases the mydriatic effect, but tends to prevent *conjunctivitis:*

℞	*Homatropin. hydrobrom.*	0·26 gm.
	Cocain. hydrochlor.	0·65 gm.
	Acid. salicyl.	0·06 gm.
	Aq. distil. ad	30 ml.

or *Lamella homatropin. hydrobrom.* and *Cocain. hydrochlor.* āā 0·0013 gm.

119. Complete paralysis of accommodation is effected in about three-quarters of an hour. The effects pass off in from twelve to twenty-four hours. In adults, when the examination is concluded, one drop of solution of eserine (0·06 grm.—30 ml.) should be applied.

120. In astigmats, whatever the meridian decided upon for the axis of the cylinder while under the influence of a cycloplegic, this must on no account be changed subsequently.*

121. The reading vision should not be tested until the effects of the cycloplegic have passed off, as the accommodation being paralysed, the patient is unable to negotiate the divergent rays reflected from a book at a comfortable reading distance.

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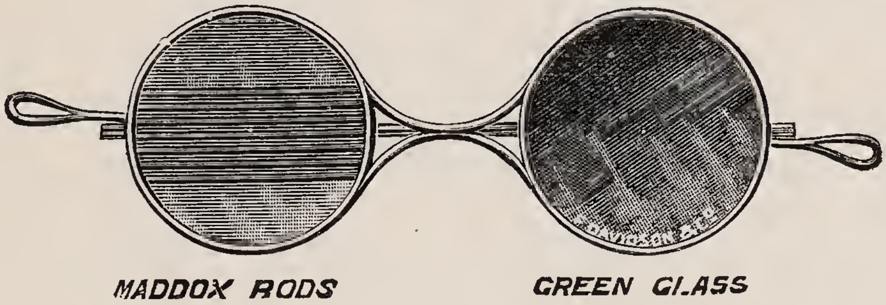
* Care must be taken to make allowance for the influence of the cycloplegic, it being usually necessary slightly to reduce the correction in hypermetropes, and to increase it in myopes, by, say, ·75 if there is 1·5°, ·50 if 1·0°, 1·0 if there is 2·0°. A hypermetrope of + 3·5 would have + 1 D less.

(*Heterophoria.*)

122. The eyes must be examined with both distant and near point tests, the former first, then the latter. The test card is reversed (Fig. ix.), a light placed opposite the black spot, and the patient seated 3 m. (10 ft.) from the card. Both eyes are kept open during the examination. Where refractive conditions are known to exist the correction should be worn during the test.

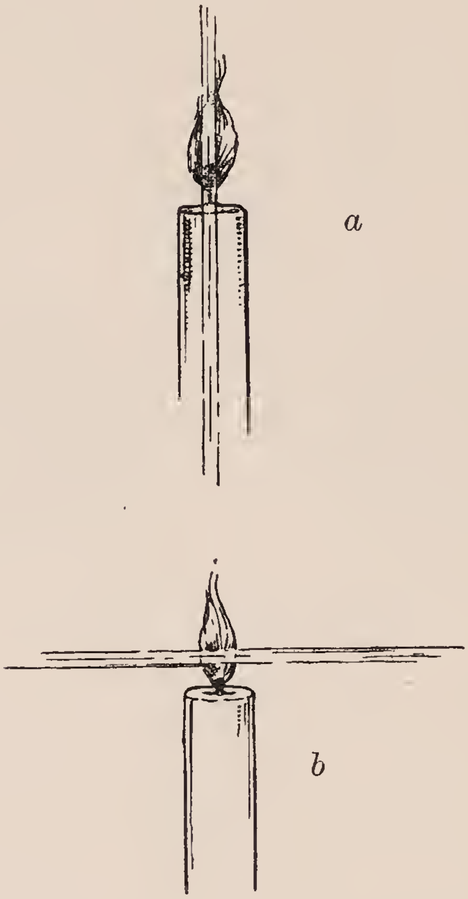
Fig. x.



123. The light when seen through the Maddox rods (Fig. x.) under a condition of perfect equilibrium (*orthophoria*), is seen as a long red streak through the middle of the flame, but in the opposite meridian to that in which the rods are placed—vertically when they are placed horizontally (Fig. xi. *a*), and horizontally when they are placed vertically (*b*). The glass rods are sufficiently loose in the frame to allow of rotation. Any variation in the position of the

streak (in relation to the flame) shows want of harmony between the convergence and the accommodation, and heterophoria in some form or another will be found to exist.

Fig. xi.



124. Where refractive error exists with heterophoria, the effect of correcting the former should be tried first before resorting to prismatic correction, as it is possible that the heterophoria may be produced by the former. If the muscular asthenopia still persists, prisms may then be resorted to.

125. The prism should be placed with its base in the same direction as the streak appears in relation to the light, *out* in esophoria, *in* in exophoria. It will then bring the streak into its true position and show the amount of deviation.

126. On first wearing prismatic glasses some discomfort may be experienced, for two or three weeks perhaps, but the patient will gradually become accustomed to them.

(*Spectacles.*)

127. When measuring for spectacles, care must be taken that the centres of the lenses correspond as nearly as possible with the centres of the pupils. Those intended for reading or near work only may be allowed to converge slightly.

128. Spectacle frames are measured from the outside rim of one eye-piece to the inside rim of the other, which measurement will be found to coincide exactly with the distance between the centres.

129. All glasses, except those for presbyopes, should be worn as close to the eyes as the lashes permit. The recognised distance is 13·7 mm. in front of the cornea. Presbyopes may wear them according to their own inclination,

the distance from the cornea generally being about 2·5 cm. (or 1 in.). Myopes should wear their glasses for reading and near work continually.

130. Spectacles are best in all cases, but if they are objected to, horizontal clips may be used for myopes and astigmats. Folders are only suitable for presbyopes and should never be used with astigmatic (cylindrical or compound) lenses. For presbyopes, who use glasses only for near work, spectacles are used for home work, while folders—which require only one hand to place them in position—are generally used for the pocket.

XIII. Preliminary Tests (on Letters only).

	Suspect.	Go on to
131. i. Use *naked eye* (for acuteness of vision). Note result.		
ii. Use *convex sphericals* (for hypermetropia).		
(*a*) If vision normal or not, and there is improvement:	Hypermetropia	132
(*b*) If vision not normal, and partial improvement only:	comp. hyper. astig.	134

	Suspect.	Go on to
(*c*) If vision not normal and improvement doubtful, or no improvement at all— iii. Use *convex cylinders* (for hypermetropic astigmatism and myopia). Rotate starting ↓.		
(*a*) If one meridian improved, and the opposite made worse (because probably emmetropic), but normal vision obtained with this lens alone :	simple hyper. astig.	133
(*b*) If one meridian improved, opposite made much worse, but normal vision not obtained with this lens alone :	mixed astig.	135
(*c*) If equally worse in every meridian :	myopia	136
(*d*) If worse in every meridian, but more so in one meridian than in another— (iv) Use *concave cylinders* (for myopic astigmatism). Rotate starting →.		

	Suspect.	Go on to
(*a*) If one meridian improved (the meridian made worse with convex cylinders); the opposite made worse (because probably emmetropic); and normal vision obtained with this lens alone:	simple myopic astig.	137
(*b*) If one meridian improved, but normal vision not obtained with this lens alone:	comp. myopic astig.	138
v. There being no refractory error, or a trivial one only; or normal vision not obtained during any of the above tests:	heterophoria.	§ xv

XIV. CONFIRMATORY TESTS.

HYPERMETROPIC TESTS.

Hypermetropia.

132. Whether letters read or not read normally, if vision is good or improved with spherical convex lens, the diagnosis of hypermetropia is complete.

Correction : The strongest spherical convex which gives best results (107).

Simple Hypermetropic Astigmatism.

(See 108 and 109.)

133. Having noted the defective meridian, say 15°, which was improved with cylindrical convex lenses, say 1·0, on letters, verify this meridian on lines, exposing those normal for distance, and add a further + 0·5 to the above lens = 1·5 (106). This angle will be found to correspond with the defective meridian. Then test the opposite meridian, 105°, on lines with the naked eye, and if vision is normal the diagnosis is complete.

Correction : The strongest convex cylinder (45) with which letters can be read at normal distance, axis in defective meridian (111).

Formula : Cyl. + 1·0, ax. 15°.

Compound Hypermetropic Astigmatism.

134. Having noted the strength of the spherical convex lens, say 1·5, which gave partial improvement only on letters, proceed to find the meridian of G.D., *i. e.* the most hypermetropic (62). To the above lens add a further 0·5 = sph. + 2·0 (105), and test on lines. Com-

mence by exposing largest lines, gradually reducing the size until the least is found that can be counted. Then find the meridian in which they are best seen—say 15°—by rotating the disc. This is the meridian of G.D. Discard this lens. Then test lines in the opposite meridian (that at right angles to it), the meridian of L.D.—105°. If found to be hypermetropic, the diagnosis is complete. The condition of this meridian will show whether it is a case of compound or simple hypermetropic astigmatism, or mixed astigmatism. Now use the naked eye; then add convex spherics till the strongest is found which gives best results, say + 0·50. This will be the *spherical* correction.

Result: Sph. + 0·50 in meridian 105°.

With the above lens (sph. + 0·50) draw attention to letters and place in front of the eye cylinders with axes in meridian of G. D. (15°), till the one is found which gives the best results, say + 1·0. This is the *cylindrical* correction.

The *total* correction is the sum of the two lenses, and the *formula:* Sph. + 0·50 $\overset{\frown}{\smile}$ cyl. + 1·0 ax. 15°. We have thus + ·50 D. in mn. 15°, and + 1·50 D. in mn. 105°.

Confirm by rotating the cylinder to either side.

Mixed Astigmatism.

135. Having noted the meridian which was improved with the convex cylinders on letters, say horizontal, we diagnose *hypermetropic astigmatism* in this meridian (109). To complete the examination, test the opposite meridian, the vertical (which gave the best results with the naked eye, and was made much worse with the *weakest* convex lens), with weak concave cylinders on letters, axes in this meridian. *Myopia* will at once be made manifest. Now proceed to find the *amount* of defect in each meridian.

Expose lines on dial, normal for distance: (*a*) First test the hypermetropic meridian (the horizontal) by rotating the dial, and placing lines in that meridian, with convex sphericals. The strongest with which the lines can be counted denotes the *amount of hypermetropia*, say + 2·0. (*b*) Then test the myopic meridian, the vertical, by placing lines in that meridian, with concave sphericals. The weakest with which the lines can be counted denotes the *amount of myopia*, say – 1·0.

Total result: Hypermetropia of + 2·0 in the horizontal meridian and myopia of − 1·0 in the vertical meridian. The sum of the two denotes the *amount of astigmatism*, and the strength of the cylindrical lens required.

Correction: Cyl. + 2·0, ax. h., ○ cyl. − 1·0, ax. v., which reduced to a spheric and a cylinder, give the following:

Formula: Sph. + 2·0 ○ cyl. − 3·0, ax. v.

The sph. + 2·0 corrects the hypermetropia in the horizontal meridian, but makes the myopia in the vertical meridian more myopic, by − 2·0, than before, which is corrected by − 3·0.

Alternative formula: Sph. − 1·0 ○ cyl. + 3·0 ax. h.

Here the sph. − 1·0 corrects the myopia in the vertical meridian, but makes the hypermetropia in the horizontal meridian more hypermetropic by − 1·0, necessitating + 3·0 instead of + 2·0 D. to correct it.

Myopic Tests.

Myopia.

136. Test (*a*) with the naked eye on lines. *Result:* Vision equally bad in every meridian. (*b*) With concave sphericals on letters. *Result:*

Vision normal with this lens alone. The diagnosis of myopia is complete.

Correction: The weakest concave spherical that gives the best results.

Simple Myopic Astigmatism.

137. Vision is made worse in every meridian with convex cylinders.

Test with naked eye on lines. *Result:* Vision $= \frac{6}{36}$. Lines in one meridian, say the horizontal, are corrected normally, but those in the opposite meridian, the vertical, cannot be corrected. Then test the lines in the opposite meridian with weak concave cylindricals, axis in this meridian.

Result: Vision $= \frac{6}{6}$, and the diagnosis is complete.

Correction: The weakest concave cylindrical, say – 0·5, with which lines can be counted normally, axis in defective meridian (the vertical). Verify on letters.

Formula: Cyl. – 0·5, ax. v.

Compound Myopic Astigmatism.

138. There was no improvement with convex lenses. One meridian improved with concave

cylinders, but normal vision not obtained with this lens alone.

Test (*a*) with the naked eye: Vision = $\frac{6}{36}$; lines not counted in any meridian. (*b*) With concave sphericals, say 2·0 on letters, find the weakest giving best results. Then change lens to 0·5 less (106) = sph. – 1·5, and find the meridian of L.D., which is the meridian in which lines are best counted, say the horizontal. The weakest is the *spherical correction*, say, – 1·0 D. Test the opposite meridian, the horizontal, for the *cylindrical correction*. To the spherical correction – 1·0, add cylindrical lenses, say 2·0 D., axis in meridian of greatest defect (the vertical) and find the weakest with which letters can be read and lines counted in both meridians at normal distance.

Formula: Sph. – 1·0 ⊂⊃ cyl. – 3·0, ax. v. We have here – 1·0 D. in the v. mn., and – 3·0 in the h. mn.

XV. HETEROPHORIC TESTS.

139. The refractive element, if any, should be worn, and both eyes remain open during examination.

(*a*) *The Distant Point Muscle Test.*

(With the Maddox Multiple Rods; see 123).

140. The disc of the Maddox-rods fits sufficiently loosely in its frame that it may be rotated with the finger and thumb, bringing the rods into either a horizontal or vertical position. The spectacle frame can also be reversed for use with either eye.

For Esophoria and Exophoria.

141. Place the rods horizontally and test. (*a*) If the vertical streak of light appears on the *outside* of the flame, *i. e.* away from the nose, the eyes converge too much, the visual lines deviating inwards, and *esophoria* exists. (*b*) If the vertical streak appears on the inside of the flame, *i. e.* towards the nose, the eyes diverge, the visual lines deviating outwards, and *exophoria* exists. For instance:

On testing the two eyes with rods horizontal; with the right eye the vertical streak is seen 8° to the outside of the streak, *i. e.* to the right, and with the left eye the vertical streak is seen 4° to the outside, *i. e.* to the left, we have 12° of esophoria between them, which divided by 4 =

3. Half of this for each eye might be safely given at first, and increased later if necessary.

Formula: B.E. prisms 1½°, B. out.

On testing the two eyes with rods horizontal; with the right eye the vertical streak is seen 3° to the inner side of the flame, and with the left eye the vertical streak is seen 5° to the inner side, we have 8° of exophoria, one fourth of which is 2°. Half of this at first for each eye = 1°.

Formula: B.E. prisms 1°, B. in.

For Hyperphoria.

142. Place the rods vertically and test: (*a*) If the horizontal streak of light appears *below*, left hyperphoria exists; (*b*) if the horizontal streak appears *above*, right hyperphoria exists. The amount of deviation in each case is shown by the number on the card nearest to the streak, and by the prism in front of the rods which brings the streak through the middle of the light.

Corrections for Heterophoria.

143. If the aggregate muscular deficiency in both eyes is less than 16°, one fourth of the total amount for each eye is the maximum or limit. The limit should never be given at first, but

about half; and it is never advisable to use a stronger prism than 4°.

For esophoria with hypermetropia: The convex lens corrects both defects, for while improving the hypermetropia, it improves also the esophoria. The full correction of the refractive error is therefore given. The glasses to be worn constantly. No prisms.

For esophoria with myopia: The full correction for the myopia to be given. Prisms, bases out. Near work to be given up for a time.

For exophoria with hypermetropia: Less than the full correction of the hypermetropia to be given. The convex lens, while correcting the hypermetropia, aggravates the exophoria by increasing the divergence of the visual axes. The prisms, bases in, to be kept as weak as possible.

For exophoria with myopia: The myopia to be fully corrected. Prisms, bases in.

For exophoria with presbyopia: The weakest convex lens to be given. Prisms, bases in.

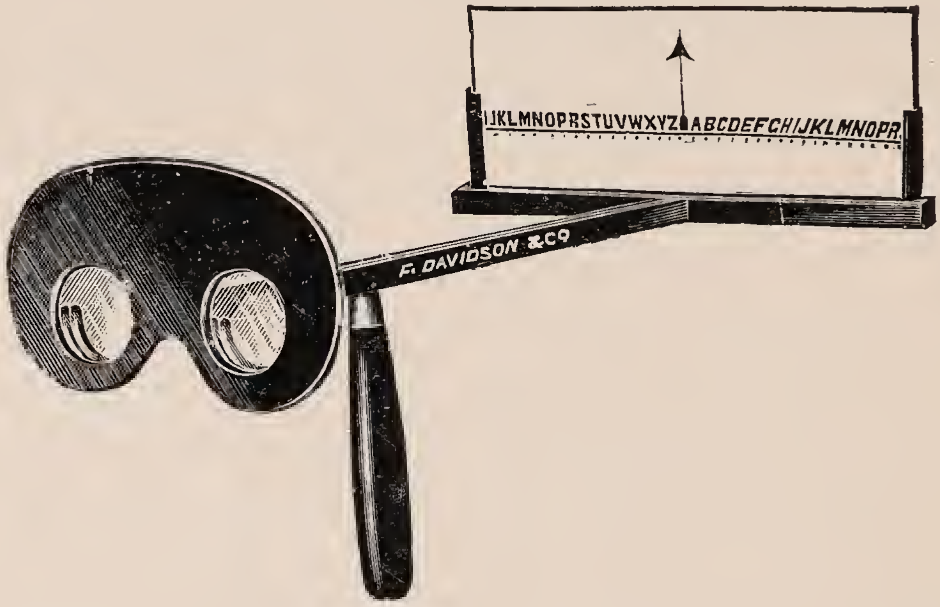
For hyperphoria: See 122.

(*b*) *The Near Point Muscle Test.*

144. The near point muscle test (Fig. xii) is a frame in which is inserted a pair of prisms,

bases up for one eye, bases down for the other. The rod carries a small card at a distance of 25 cm. The appliance is held by the handle in front of the eyes, the rod between the eye-piece and the card being perfectly horizontal. The patient then looks at the card, diplopia resulting, and two lines of letters and two arrows are seen, one set below the other. If muscular conditions are normal the lower arrow will be seen immediately below the upper one. He is then asked to which side of the upper arrow the lower one appears, and under which letter. If to the right, there is latent convergence (*esophoria*); if to the left, latent divergence (*exophoria*). The degree marked under the letter denotes approximately the

Fig. xii.



angle of the prism required to produce normal conditions and bring the lower arrow exactly beneath the upper. It is generally advisable to follow up this diagnosis by confirming it with the prism.

Correction: Deviations to the left (*exophoria*) require prisms, bases in or towards the nose; deviations to the right (*esophoria*), prisms, bases out. In myopes showing a deviation to the left, prismatic correction is nearly always desirable. Slight deviations need not be taken into consideration, but when over 2°, may be corrected by prisms of about one-fifth for each eye. For instance, if the lower arrow is found 5° to the left, a prism of 1° for each eye, bases in, would be indicated.

XVI. PRESBYOPIC TESTS.

Presbyopia.

145. The lenses generally required are:

At age .	45	50	55	60	65	70	75
Dioptres.	·5	1·0	1·75	2·5	3·5	4·5	5·5

146. The distant vision should always be tested first to detect hypermetropia, myopia or astigmatism. Note the result, and test the

near vision with the reading type, which should not be done too hurriedly.

Correction: The weakest convex spherical lens which enables the patient to read at a comfortable distance, generally from 36 to 38 cm. (14 to 15 in.) Stronger lenses may be used for close work, and weaker ones for more distant work if required.

Presbyopia with Hypermetropia.

147. Hypermetropes of over forty years of age generally are presbyopic. Test the distant vision with lenses that correct the hypermetropia. Then find what additional lens is necessary for reading. The lenses which correct the hypermetropia only are to be worn constantly. Separate glasses for reading must be used.

Presbyopia with Myopia.

148. Concave lenses will be required for distance, according to the age of the patient and the amount of myopia (under 3·0 D., see 56).

Presbyopia with Hypermetropic Astigmatism.

149. Add to the lens that corrects the hypermetropic astigmatism, spherical lenses that

correct the presbyopia. For instance, a patient of fifty years of age requires for distance, sph. + 2 with cyl. + 2·0 ↓. On account of his age he would require for reading, sph. + 1·0, but being a hypermetrope he will probably require 1·5, for hypermetropes manifest more presbyopia than emmetropes. He would therefore require for reading sph. + 3·5 ⊃ cyl. + 2·0 ↓, the distant correction remaining the same for both distance and reading.

Presbyopia with Myopic Astigmatism.

150. In myopic astigmatism of 2·5 or less, first reverse the cylindrical correction for distance; and if this is not sufficient to allow of small print being read near enough, add the weakest convex spherical lens giving normal vision. A patient fifty years of age requires for distance, cyl. — 1·0 ↓; for his presbyopia he requires sph. + 1·0 = cyl. + 1·0 →. In myopic astigmatism of over 2·5 D., give a convex spherical with the same concave cylinder required for distance.

Presbyopia with Compound Myopic Astigmatism.

151. Suppose that there is myopia in the vertical meridian of 1·5, and in the horizontal

meridian of 0·75, the correction for distance is sph. — 0·75 ⊃ cyl. — 0·75 ↓. There is therefore in the horizontal meridian — 1·5 and in the vertical — 0·75. If the patient is fifty years of age, correct the presbyopia, say 1·0, by making the vertical meridian as myopic as the horizontal, and by giving a cyl. — 0·75 ↓. The patient is now equally myopic in every meridian, which is sufficient at that age. At sixty to sixty-five years of age give cyl. + 0·75 →, which makes the patient equally myopic to 1·5, and if this is not sufficient, add the weakest convex spherical that will enable him to read. It is well to bear in mind the distance of the p.r. for reading when making the patient equally myopic in every meridian, for when giving a convex cylinder in order to effect the above purpose the p.r. may be too near for reading. A patient requires cyl. — 4·0 D. ↓; the cylinder is reversed, giving cyl. — 4·0 →, making him equally myopic in every meridian, but with a p.r. at 25 cm., which is too near.

Presbyopia with Mixed Astigmatism.

152. The correction is the same as in presbyopia with myopic astigmatism, when the myopia

required 2·5 or less. First make the patient equally myopic by giving a convex cylinder, axis in the hypermetropic meridian, of the strength of the hypermetropia and the myopia combined. When the myopia is more than 2·5, retain the concave cylinder and add a convex spheric, to give comfortable reading sight.

PART III

XVII. OBJECTIVE SIGHT-TESTING—"RETINOSCOPY."

(*General.*)

153. Retinoscopy, or objective sight-testing, called also "the shadow test," can be easily learned by practice with the model eye.

154. It is useful in cases of astigmatism of low degree in amblyopia (84), where the visual acuteness remains below normal, and is an unfailing test against malingering. For it to be successful the transparent media should be clear and there should be no photophobia.

155. It is better if possible for the pupils to be dilated and accommodation paralysed by a cycloplegic (113).

156. The right eye should be tested first, the opposite eye-piece of the trial frame being closed.

(*Mode of Examination.*)

157. The patient is seated in a dark room, with a light (a 32 Watt electric lamp, an Argand gas burner, or an oil lamp) behind and above him, so that his face is placed in shadow, and wearing the trial spectacle frame. The operator (wearing his correcting glasses if his distant vision is faulty), with an ophthalmoscopic plane mirror in his hand, seats himself facing the patient, the eyes of both being on the same plane, and at a distance of 120 to 150 cm.* The patient, *if under* the influence of a cycloplegic, is directed to look steadily at the central hole in the mirror; *if not under* such influence, is directed to look beyond the mirror slightly inwards towards his nose, but on no account must he look directly at the mirror. The operator, holding the mirror in position opposite the light, looks through the central opening, and throws the reflection upon the patient's retina, the small illuminated portion of which

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* In former days a concave mirror was used when it was necessary for the operator to sit closer, but this is now almost universally discarded for the plane mirror, which gives a true image of the fundus, and by which shadows are better seen and the results more exact. If, however, a concave mirror be used, the resulting shadow in every case moves in the reverse direction.

is termed the "red" or "fundus reflex"—bright in the emmetrope, but less so in the ametrope—when the shadow surrounding it must be carefully looked for and watched, for it is by the direction in which the shadow moves when the mirror is revolved that the case can be correctly diagnosed.

158. The image of the reflected light in hypermetropia is an erect one formed *behind* the eye, whereas in myopia it is an inverted one formed *in front of* the eye.

TESTING THE SHADOW.

159. Both meridians must be examined separately, first by revolving the mirror on its vertical axis for the horizontal meridian, then on its horizontal axis for the vertical meridian.

160. When the mirror is revolved (on either axis): (1) If the shadow moves "with" it, *i. e.* in the same direction as the circle of light, the refractive defect is *hypermetropic ;* (2) if the shadow moves "against" it* the refractive defect is *myopic ;* (3) if the shadow is neutralised and appears to turn over on itself the eye is

---

* Provided the operator is not nearer than the patient's p.r., for in low degrees of myopia, say —5 D., where the p.r. is beyond 120 cm., the shadow will move "with."

emmetropic; (4) if the refraction in the two meridians differs *astigmatism* exists.

161. The slower the shadow is in moving, the less distinct it is, and the duller the reflex, the *higher is the degree* of ametropia. The quicker the shadow moves, the more distinct it is, and the brighter the reflex, the *lower is the degree* of ametropia.

162. The refractive defect (if any) being discovered, proceed to find the amount in either or both meridians by putting up in the trial frame a neutralising lens, commencing with 1 or 2 D., and continue changing them according to whether they over- or under-correct the movement of the shadow. In high degrees of ametropia the red fundus reflex is generally obscured and the shadow difficult to make out. A + 6 D. may be put up; then a — 6 D. With one or the other the ametropia will be more or less corrected and the shadow seen without difficulty. From this point the examination can be easily completed.

163. In astigmatism the illuminated area (*i. e.* the image of the light) may vary both in shape and position, being dependent upon the maximum and minimum curvature of the cornea, being sometimes oval, and at others band-like in

shape, and the edges horizontally, vertically, or obliquely disposed. The line of obliquity of the oval or band denotes the direction of the chief meridian, with which either is parallel.

164. In cases of *compound astigmatism* the vertical meridian should be corrected first.

165. In *irregular astigmatism* retinoscopy does not give satisfactory results, the shadow being indefinite and irregular.

166. In *conical cornea* the shadow is ring-shaped.

167. Having found the correcting lens which neutralises the shadow, for each eye in hypermetropia and myopia, and for each meridian in the case of astigmatism, the combination having been first put up in the trial frame, the test is confirmed by testing the distant vision subjectively with the trial card, making any alteration which may be necessary.

168. In estimating a patient's refraction by retinoscopy we must bear in mind that we do so as if his p.r. was at 150 cm., the distance between him and the operator, and his hypermetropia will be *over*- or his myopia *under*-estimated, as the case may be. To obviate this in the former case we deduct + 1 D., and in the latter we add — 1 D. to his correction. For

instance, if the shadow moves with the mirror, and + ·50 corrects, the case is one probably of weak myopia; if + 1 D. corrects, the eye is emmetropic ; and if a stronger lens is required the case is one of hypermetropia. If, however, the shadow moves against the mirror it is obviously a case of myopia, and if we get no shadow we may conclude we are practically sitting at the patient's far point.

XVIII. EXAMPLES.

HYPERMETROPIA.

169. The shadow is "with" the mirror. A + lens, say, + 1 D., is put up in the trial frame. If the shadow is still "with," this is changed for + 2 or + 3, and so on till the shadow is neutralised.

Formula : $\begin{array}{c|cl} \text{———} & \text{———} & + 3 \\ & + 3 & \end{array}$

MYOPIA.

170. The shadow is "against" the mirror. A — 1 D. lens is put up in the trial frame. If the shadow is still "against" this is changed

for − 2, and so on till the shadow is neutralised.

Formula : $$\begin{array}{r|l} \rule{1.2cm}{0.4pt} & \rule{1.2cm}{0.4pt}\ -2 \\ & -2 \end{array}$$

Simple Hypermetropic Astigmatism.

171. The shadow in the two chief meridians differs (159). That in the vertical meridian (166) is emmetropic, but that in the horizontal requires + 3 D. to neutralise.

Formula : $$\begin{array}{r|l} \rule{1.2cm}{0.4pt} & \rule{1.2cm}{0.4pt}\ +3 \\ & \text{Em.} \end{array}$$

Compound Hypermetropic Astigmatism.

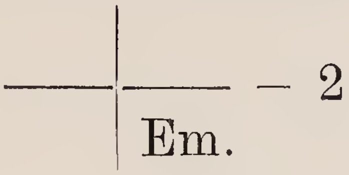
172. The shadow in one meridian, say the vertical, may be corrected with, say, + 2 D., while in the opposite meridian it is still "with." It is then apparent that both meridians are defective, but in a different degree, the shadow in the horizontal meridian requiring + 3 D. to neutralise.

Formula : $$\begin{array}{r|l} \rule{1.2cm}{0.4pt} & \rule{1.2cm}{0.4pt}\ +3 \\ & +2 \end{array}$$

SIMPLE MYOPIC ASTIGMATISM.

173. The shadow in one meridian is "against," the opposite being emmetropic.

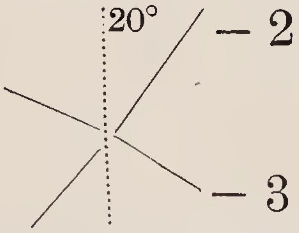
Formula :



COMPOUND MYOPIC ASTIGMATISM.

174. The shadow is oblique. Astigmatism is manifest. Correct each meridian separately, moving the mirror *at right angles to the edge of the shadow*. The amount of obliquity can generally be estimated by the eye If the vertical meridian be 20° out and requires for its correction – 2 D., and the meridian at right angles to this requires – 3 D., it is expressed as in the following formula.

Formula ;



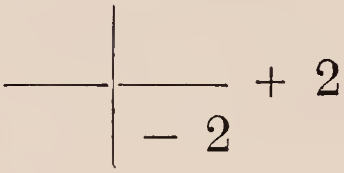
Correct with sph. – 2 ⊂ cyl. – 1 ax. 110°.

MIXED ASTIGMATISM.

175. The shadow on vertical rotation is neutralised by a + 2 D. for the horizontal

meridian, while on horizontal rotation for the vertical meridian requires − 2 D.

Formula :



Correction.—A cyl. − 2, ax. h. ⌒ cyl. + 2 ax. v. But as it is a rule in correcting refractions to reduce to a sphere and a cylinder, either of the following formulæ may be adopted, the latter for preference.

1. Sph. − 2 ⌒ cyl. + 4, ax. v.; or—
2. Sph. + 2 ⌒ cyl. − 4, ax. h.

INDEX

PAGE
Accommodation . . . 11
— range of 13
Amaurosis 34
Amblyopia 34
Ametropia 11
Angle *a*, the 10
Asthenopia 14
Astigmatism . . . 23, 73
— hypermetropic . 25, 53, 54, 77
— irregular 28
— mixed . . 25, 59, 77
— myopic . . 25, 58, 53, 77
Axis, optic 9
— principal 4
— visual 9

Conical cornea . 25, 28, 74
Cyclopleglcs . . . 22, 46

Dioptre 4
Dioptric system . . . 7
Diplopia 13
Distant point test . 49, 61

Emmetropia 10
Esophoria . . 16, 51, 61
Exophoria . . 16, 51, 61

Focal length . . . 4
— measurement . . . 4

PAGE
Focus, principal . . . 4, 8

Heterophoria . 16, 49, 60
Hypermetropia . 17, 52, 54, 72
Hyperphoria . . . 16, 62

Lens scale 5
Lenses 1
— analysis of . . . 5
— neutralisation of . . 5
— numbering of . . . 4
— prismatic 2

Maddox rods . . . 42, 49
Mensural equivalents . . viii
Myopia . . 20, 48, 53, 58, 75

Near point test . . . 63

Optic axis 9
Optical centre . . . 4
Orthophoria . . . 15, 49

Pin-hole disc . . . 45
Point, far 13
— near 13, 63
Points, cardinal . . . 7
— nodal 7
— principal 7
Presbyopia . . . 29, 65

PAGE
Presbyopic scale . . . 65
Prisms 2
Punctum proximum . . 13
— remotum 13

Reading distance . . . 66
Red fundus reflex . . 72
Refractive system . . 7
Retinoscopy 70
Retinoscopic examples . . 75

Sight-testing, notes to . . 40
— objective 70
— subjective . . . 40
Spectacles 51
Stenopaic slit . . . 28
Strabismus 31
— concomitant . . . 33
— convergent . . . 35

PAGE
Strabismus, divergent . . 35
— paralytic . . . 33, 37

Test card . . . 41, 42
Testing the shadow . . 72
Tests, astigmatic 53, 55, 57, 67, 76
— esophoric 61
— exophoric 61
— heterophoric . . . 60
— hypermetropic 52, 54, 75
— hyperphoric . . . 62
— myopic . . 53, 58, 75
— preliminary . . . 52
— presbyopic . . . 65

Vision, defective . . . 45
— normal 43
Visual angle 9
— axis 9

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INDEX.

PAGE
2 Anatomy. Physiology.
3 Materia Medica. Pharmacy.
4 Hygiene. Bacteriology.
5 Pathology. Psychology. Dictionaries.
6 Medicine.
7 Medicine.
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